Title

The revolution of sound 13 now

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Introduction

Julián Carrillo's microtonal works take place within a context of intense exploration in the field of Western music. At the same time that great composers such as Schoenberg were publishing their treatises on music theory, they also posed challenges to the theory itself, often presenting these as the most promising trends for the development of music. At this point, for some composers, the selection of twelve-tone equal temperament began to be seen as just one of many possible configurations for a set of pitches. Composers like Alois Hába or Ivan Wyschnegradsky proposed highly elaborate systems and even sought to organize tunings with 72 equal divisions of the octave (72-EDO), although still firmly operating within the standard system of 12-EDO. On the other hand, Julián Carrillo, referencing his own research more than that of other composers, advanced a proposal that, as we will see, would prove valid not only for 96-EDO but for any type of tuning. The qualities that make it optimal for adapting to different systems are the regularity of its notation system and the unlimited theoretical exploration it allows to be put into practice.

1. The current system of musical notation has primarily focused on the staff system. This method has been reinforced and defended by music academies with various arguments, becoming established as the default system for written musical representation. In contrast, significantly less development has occurred even in systems of notation for percussion and instruments without a defined pitch. For microtonal music, efforts have been made to define its written representation and attempts have been made to incorporate it into the conventional notation system. However, these efforts have been based on theoretical frameworks emerging from Western academia, often rooted in conservative and continuist perspectives — even among the most revolutionary theorists.

Julián Carrillo's notation system arises embracing the trend of renewal and universalization that was a common part of public discourse in Mexico and much of the musical academy of the time. Yet, it takes this trend to its most radical extreme, even questioning the organization through staves, considering that the standard of writing, even within the 12-EDO system, can create unnecessary problems that complicate reading.

Although Carrillo's proposal introduces novel elements, it is not entirely disruptive and can be considered to share similarities with other historical proposals. We can observe that the notation system proposed for pieces composed by Carrillo — even in his most advanced scores — still attempts to maintain a certain continuity with the tradition of musical writing. This spirit of continuity sometimes interferes with the possibilities offered by such a revolutionary proposal as the "Sound 13." For this reason, it also presents opportunities to further develop an accurate system of registration for microtonal music through scores.

The aim of this essay is to revisit the fundamental aspects of Carrillo's theory to consolidate them into a system that addresses the problems of the original theory without introducing new complications, as far as possible. Additionally, within the scope of this essay, a mathematical property is demonstrated that allows the maximum potential of such a system to be applied in xenharmonic tunings. Likewise, some experiments already conducted by me are briefly outlined.

1.1 The writing system that accompanies the proposal of "Sound 13" incorporates novel elements while resembling a generalization of the traditional notation system. The most noticeable quality it presents is the use of numbers to represent sound elements organized within a defined set. This implies that, in general, clarity is required regarding the sound each number represents, as well as indications that represent variations in their characteristics. The original proposal is still influenced by traditional

notation, and therefore, in addition to the numerical system, it retains the visual arrangement by note height to represent octave variations. This variation in height conflicts with the goal pursued by using numbers to represent sounds, since numbering simplifies the visual conception of moving up and down pitches on the staff, making the representation of its elements more compact by relying on a symbolic figure that represents them, thereby making the concept of "pitch" in scores more versatile. Due to this symbolic and abstract quality of numbers, they can equally adapt to defined tones, indefinite-pitched sounds, or even complex sonic objects. Undoubtedly, unlimited potential can be found for the development of theories applicable to equal divisions of tunings over a period.

However, traditional notation has the advantage of showing polyphonies more intuitively, and in this regard, Julián Carrillo's system faces a significant difficulty. With the original proposal, there are two ways to address this difficulty: multiple independent melodic lines can be written when dealing with polyphonies with more constant voices (Image 3), and on the other hand, vertical grouping within the same system can be used (Image 2). However, this requires notable complementation in the interpretation of the numbers as tones within a specific chordal arrangement, as additional vertical numbers are added to indicate variations in the number of voices with limited range. Additionally, the original proposal includes numbers crossed out by the line of the “absolute tone,” which elegantly saves a significant number of lines but also requires a more complex process to determine the octave to which a specific number belongs, since part of this information is inferred from the position of the number rather than the signs associated with it, especially in the case of polyphonies. The difficulty lies in the dependence of each number on its position within the grouping, rather than being interpreted individually as an obvious sign. As Benjamin (1982) states: “Chordal writing is achieved by relating all vertical numbers to the highest number and its position on the absolute C line.” Furthermore, when positioning pitches with a more complex distribution, horizontal position is also relied upon, because “the displacement of chordal octaves is indicated by movements of the numbers to the right or left,” as seen in Image 1. This property makes its use practically impossible outside the context of chords with homogeneous rhythm between their notes. If polyphonies with heterogeneous rhythms for the notes are established, this vertical arrangement becomes impractical.

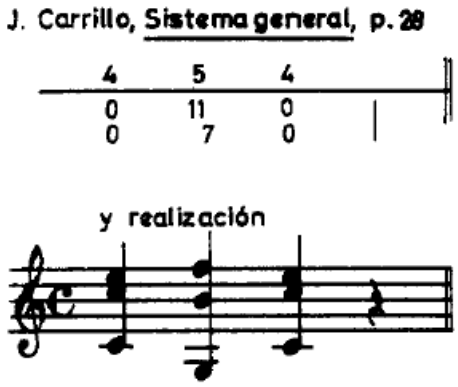

Image 1: Octave displacement

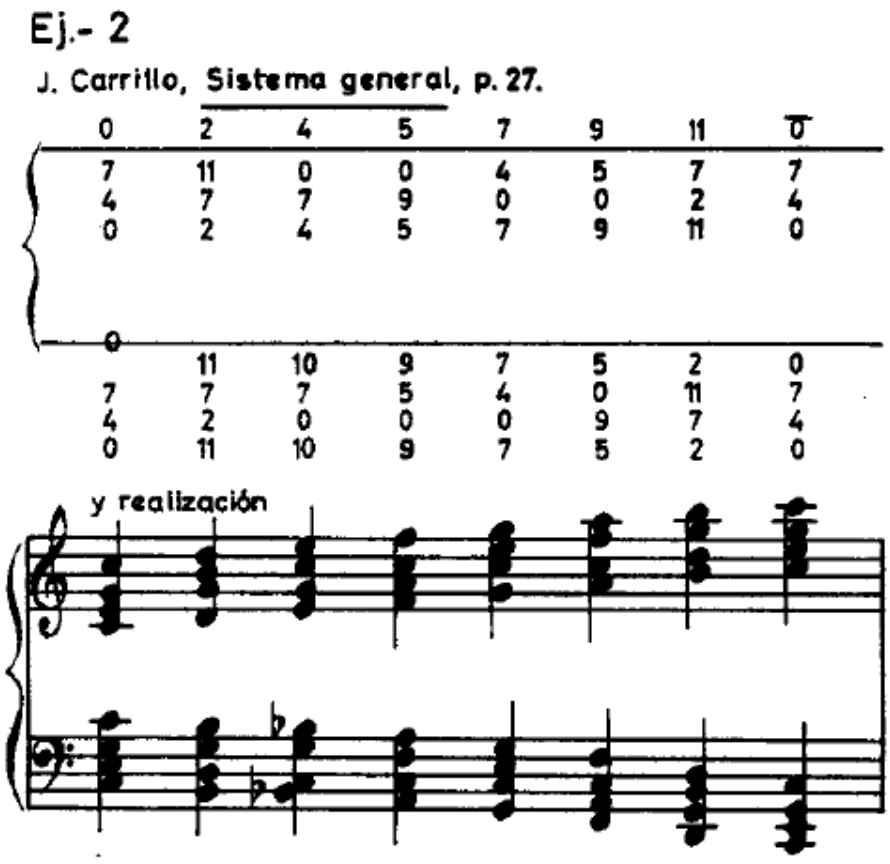

Image 2: Polyphonies in two systems

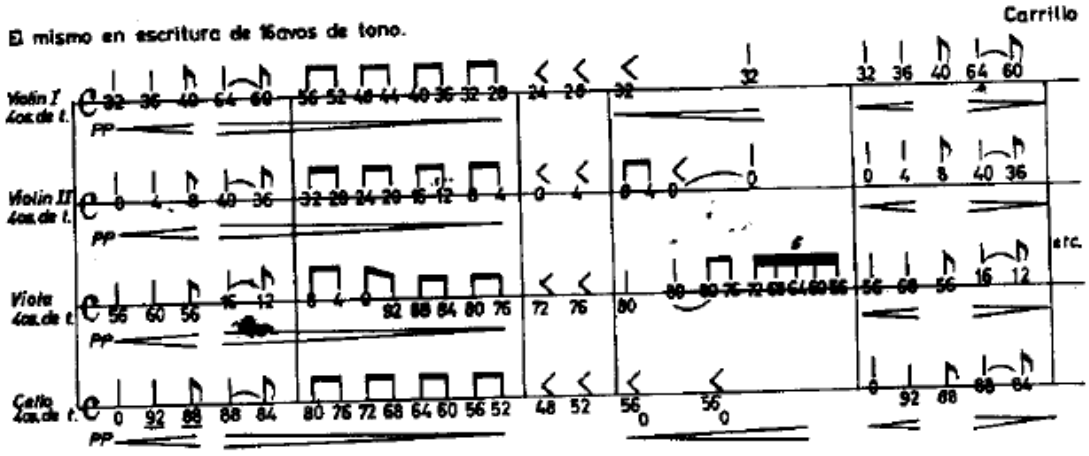

Image 3: Fragment of a polyphony

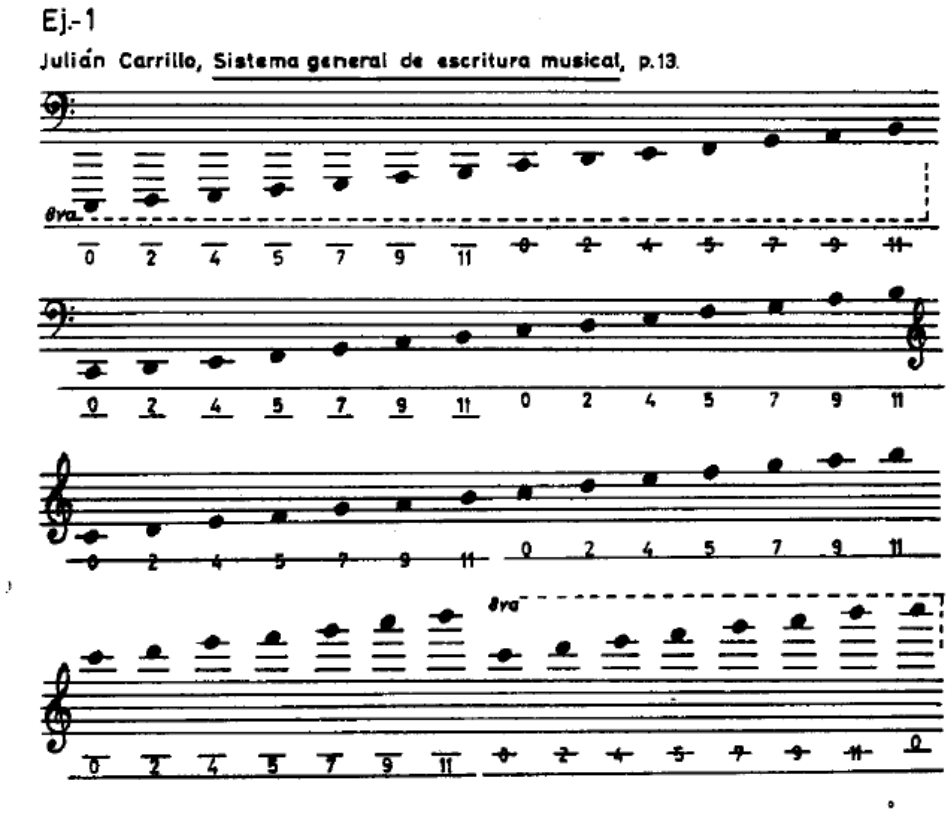

Image 4: Range of the original system

1.2 I decided to make a major change by completely eliminating the organization by pitch that was still present in the original proposal (Image 4). The current system is more similar to tablature but can also be considered a generalization of tablature, just as it can be considered a generalization of the staff, since this system allows its representation to be detached from a specific instrument. Consequently, the number of available numbers and the number of lines can be varied, as they are not associated with real strings but with the voices of an instrumental polyphony. Another strength it gains from its resemblance to tablature is that it can be easily incorporated into the music notation software Musescore, although without full functionality regarding tone variation, being limited to a visual representation. Additionally, the consistency of the rhythmic and expressive sections with respect to standard notation takes advantage of elements that facilitate learning and interpretation.

I eliminated the line that crossed out the numbers in the central register as a way to make the new height-free organization clearer and easier to interpret. In this way, the central register only presents the numbers as they are. Instead of raising the numbers above the lines — which represented octave changes when moving up in pitch — I am experimenting with a system that consists of stacking lines below the numbers. Similarly, to move down in pitch, lines are stacked above the number. Eventually, for a stack of more than three lines, it would be convenient to resort to another symbol. However, for now, the system provides adequate range for most experimental needs, so a different proposal is not yet necessary. Eventually, a solution very similar to the one used by the Maya could be adopted: writing dots for units and using a line when reaching 5 (Image 7). Both methods have their own difficulties, and neither is infallible. For the purpose of providing examples within this essay, I defined the line-

based method. However, the dot-based method or any similar approach is valid as long as it maintains consistency.

Regarding polyphonies, this system allows for the easier incorporation of parallel melodic lines within the same system. However, as in the original proposal, it is advisable to use separate systems for parallel melodic lines that involve complex polyphonies.

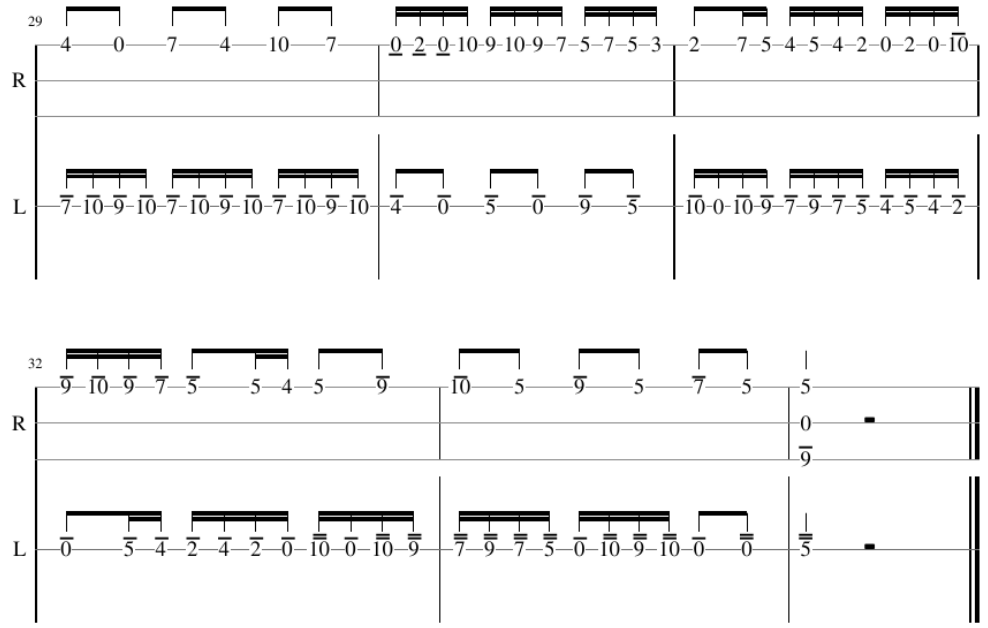

Image 5: Last notes of BVW779 in the general system
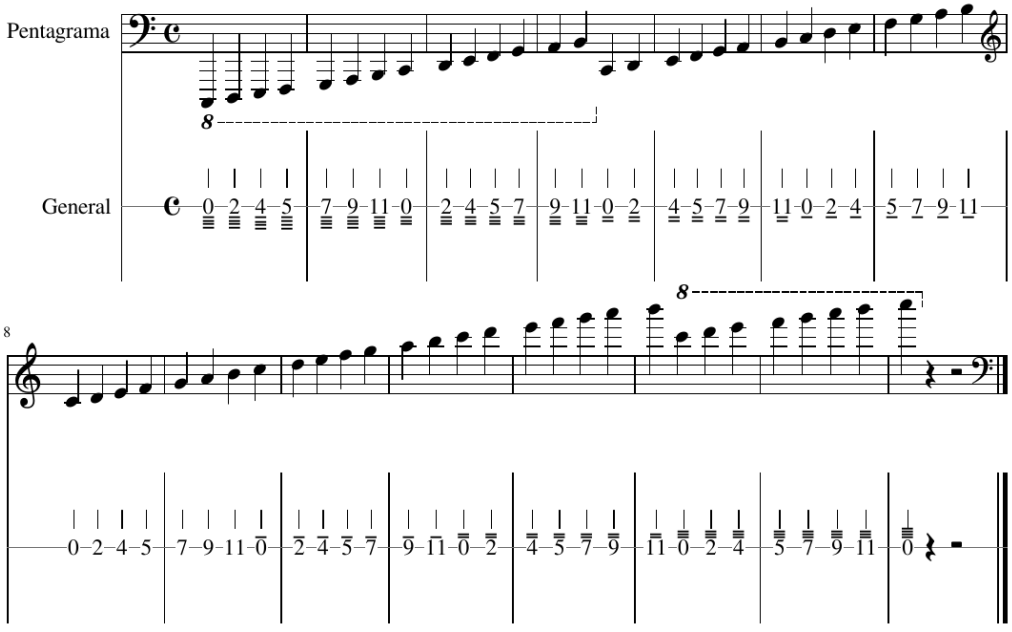
Image 6: Range for the general system

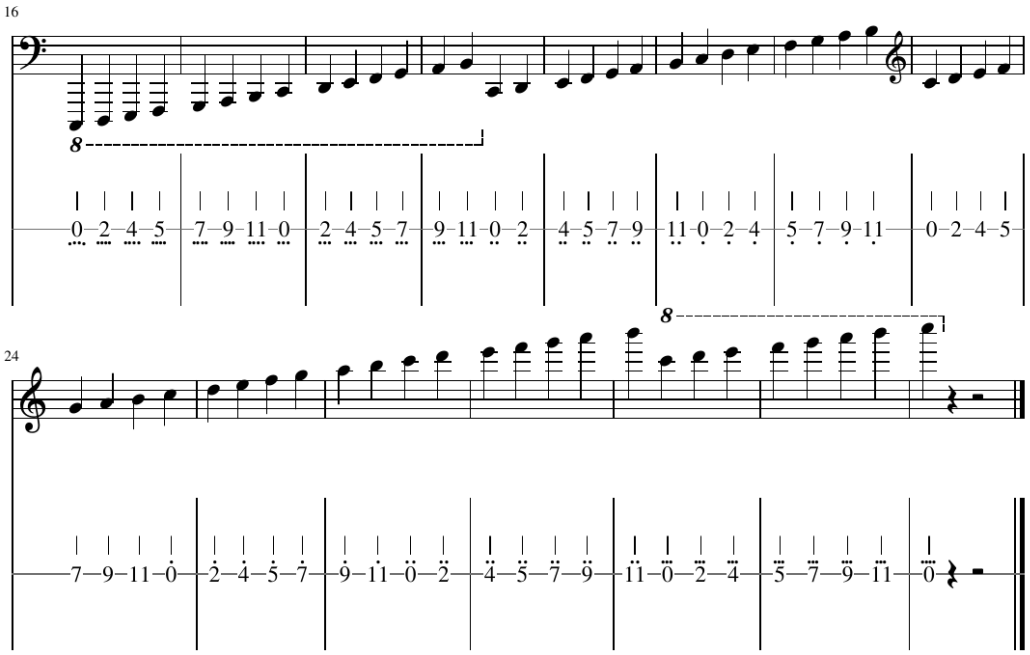

Image 7: Dot-based method

2. Associated with this writing system is a mathematical system that runs in parallel, but only as a theoretical connection and not as a requirement or method of justification for it. Undoubtedly, it can be useful when working with xenharmonic tunings and may serve as a reinforcement for exploration through this system, but auditory perception will always remain the empirical guide for any composition.

2.1 The organization obtained through the measurement of cents is similar to the organization performed by a MIDI synthesizer to associate keys with specific tones, because in both cases a base-12 system is used to organize pitches at equal intervals. If we view the organization of MIDI signals within a standard synthesizer in the most general way, we can compare the theory of acoustic music with the theory of electronic music. For this, it can be said that the cents scale is like musical intervals (minor 3rd, diminished 5th, major 7th, etc.), and the MIDI scale is like notes in their specific realization within the tuning standard (C4, D4, E4, etc.). This similarity lies in the fact that cents and musical intervals are not associated with a specific frequency nor do they depend on a particular tone or frequency to be applied, because they depend on a relationship of quantities. On the other hand, notes, according to their names, are usually associated with a standard frequency, where A4 = 440 [Hz]. Similarly, the numbers within the MIDI signal organization follow a standard where 60MIDI = C4 = 261.6 [Hz]. The purpose of this generalization is to apply these concepts to xenharmonic music. In calculations, we will encounter rational and irrational numbers, and therefore it is convenient from now on to separate the term “MIDI” from its immediate realization as an electronic signal and also from its role as a specific key on a controller.

A general formula can be obtained that relates any frequency *f* to a value *n* [MIDI] within the 12-EDO tuning standard. Likewise, for the frequency *f*, a value *m* [MIDI*] can be obtained that is associated with any kind of reference ratio, where 12-EDO is only a particular case. Furthermore, below it is demonstrated how to relate *n* and *m* to compare intervals between tunings, for example, to determine what the 7th degree of 13-ED3 corresponds to in 12-EDO, or vice versa.

To obtain n [MIDI] and m [MIDI] as reference methods:

(1.1)

$$n = 12 \cdot \log 2(f / C)$$

(1.2)

$$m = T \cdot logQ(G)$$

where:

f = frequency in Hz for n

C = reference frequency C0 = 8.17 Hz

T = number of notes per cycle

Q = value of the octave, pseudo-octave

G = any proportion

$(any\ number\ x > 0\ such\ that\ \in \mathbb{R}, for\ example: 3/2, 6/5, 2, 3, 1.51923, etc.)$

in (1.1) G = f / C can be equated, and then with respect to G to obtain:

→

$$2^{\frac{n}{12}} = Q^{\frac{m}{T}}$$

→

$$\ln 2 \cdot \frac{n}{12} = \ln Q \cdot \frac{m}{T}$$

therefore, we obtain:

(2.1)

$$n = m \cdot (\frac{12 \cdot \ln(Q)}{T \cdot \ln(2)})$$

(2.2)

$$m = n \cdot (\frac{T \cdot \ln(2)}{12 \cdot \ln(Q)})$$

that is:

$$n = k \cdot m$$

where:

$$k = \frac{(12 \cdot \ln(Q))}{(T \cdot \ln(2))}$$

$$m_1 = m_2 \cdot K$$

where:

$$K = \frac{(T_1 \cdot \ln(Q_2))}{(T_2 \cdot \ln(Q_1))}$$

In this way, with (2.1), the value of *n* [MIDI] corresponding to a value of *m* [MIDI*] can be calculated. That is, an interval that does not belong to 12-EDO can be converted into its equivalent as an interval within 12-EDO. Likewise, with (2.2), an interval within 12-EDO can be converted into its xenharmonic equivalent.

For example, if we want to convert an interval from 13-ED3 to its equivalent in 12-EDO, we would apply formula (2.1). In this case, if we convert degree 8 of 13-ED3 into its 12-EDO equivalent, we have $m = 8$, $T = 13$, $Q = 3$. Then:

$$n = 8 \cdot 1.463$$
$$n = 11.7043$$

Since 11.7043 [MIDI] is close to 12 [MIDI], it can be concluded that degree 8 of 13-ED3 is a tone close to degree 12 of 12-EDO. And since [MIDI] values are equivalent to [cents], it is seen that it is below the octave by approximately 30 [cents].

The same principle can be applied to compare two intervals m_1 and m_2 belonging to any two xenharmonic tunings. Of course, the result will no longer be within the cents system and can only be considered a general case for [MIDI*] values of any reference scale. This is done using the general formula (3.1):

(3.1) $$m_1 = m_2 \cdot K$$

Where:

(3.2) $$K = \frac{(T_1 \cdot \ln(Q_2))}{(T_2 \cdot \ln(Q_1))}$$

For example, if we evaluate degree 10 of the tuning 23-ED5 relative to the tuning 13-ED3, we can substitute into formula (3.1) with: $T_1 = 13$, $Q_1 = 3$, $m_2 = 10$, $T_2 = 23$, $Q_2 = 5$. Then:

$$m_1 = 10 \cdot 0.828$$
$$m_1 = 8.28$$

From this, it can be concluded that degree 10 of 23-ED5 does not correspond to any exact degree of 13-ED3, but it lies slightly above degree 8, approximately one-quarter of a unit higher.

2.2 There is another property that can be observed when considering tunings and their degrees using this numbering system. We can see how it emerges by analyzing the 12-EDO tuning. If we choose this tuning, its qualities will be linked to those of the number 12, which is divisible by 6, 4, 3, and 2. This implies that the tunings 6-EDO, 4-EDO, 3-EDO, and 2-EDO are subsets or scales within 12-EDO. Thus, it can be verified that 6-EDO is a subset of 12-EDO, corresponding to the whole-tone scale, where there is an interval of one tone between each note. This means that if we write out the equivalent degrees of each tuning extensively, it looks like this:

[6ED2]: 0, 1, 2, 3, 4, 5, 6
[12ED2]: 0, 2, 4, 6, 8, 10, 12

Where it is evident that the degrees of 6-EDO have been multiplied by 2. Therefore, in a 12-EDO tuning, degree 10 is exactly the same as degree 5 in a 6-EDO tuning, meaning that these degrees are at the same distance in cents relative to the root note 0.

We can verify that this property, being related to the properties of numbers, holds true for any tuning within the same octave or pseudo-octave of reference. For example, if we compare 5-EDO and 15-EDO:

[5ED2]: 0, 1, 2, 3, 4, 5
[15ED2]: 0, 3, 6, 9, 12, 15

It is evident that the degrees of 5-EDO have been multiplied by 3 to obtain degrees within 15-EDO with an equivalent size in [cents]. However, if we compare the [cents] of each degree, the [cents] corresponding to each degree of 5-EDO are actually divided. Degree 1 of 5-EDO has 240 [cents], as does degree 3 of 15-EDO, which can be summarized as:

{1, 5ED2}={3, 15ED2}

But degree 1 of 15-EDO has 80 [cents], meaning:

{1, 5ED2} / 3 = {1, 15ED2} = 80 [cent]

In fact, Julián Carrillo used this principle in his own way to design the metamorphic pianos, as they follow a generative principle that can be visualized in this way:

{1, 6ED2} = 200 [cent]
{1/2, 6ED2} = {1, 12ED2} = 100 [cent]
{1/3, 6ED2} = {1, 18ED2} = 66.6 [cent]
{1/4, 6ED2} = {1, 24ED2} = 50 [cent]
etc.

Based on this basic property, an important consideration must be made regarding number theory, which also applies to xenharmonic tunings. We must observe how, in the generation of all integers, prime numbers appear as factors. In the same way, prime numbers are the basis of all tunings. For example, 12-EDO is formed only with the primes 2 and 3. If we create tunings based on other prime numbers, the values in [MIDI] and [cents] for the formed degrees will have rational figures because they perform a division over the base 12 with factors other than 2 and 3.

From this, we can define the *regular generator interval*, which corresponds to the interval that allows reconstructing any equal division tuning (EDO) by only knowing the information expressed in the form {1, XEDY}, where 1 is degree 1 within the tuning, and X and Y are two real numbers.

Then, the {1, XEDY} for any prime number X will be the basis for constructing tunings with intervals associated with the prime number and will contain relevant information about the entire tree of tunings XEDY that can be constructed as factors of X.

For example, for all XEDY tunings that are even, it is known that X will be a factor of 2, and therefore, all even tunings will have the interval {1, 2EDY}. This can be applied to 12-EDO: we know that one of

the factors of 12 is 2, so the interval {1, 2ED2} = 600 [cents] belongs to 12-EDO, which can be verified since:

{1, 2ED2} = {6, 12ED2} = 600 [cent]

The same happens for other tunings with even divisions:

{1, 2ED2} = {7, 14ED2} = 600 [cent]
{1, 2ED2} = {8, 16ED2} = 600 [cent]
{1, 2ED2} = {13, 26ED2} = 600 [cent]
{1, 2ED2} = {31, 62ED2} = 600 [cent]
etc.

And of course, this type of interval can be found in all tunings associated with prime numbers, forming trees like this one associated with the number 3:

{1, 3ED2} = {2, 6ED2} = 400 [cent]
{1, 3ED2} = {4, 12ED2} = 400 [cent]
{1, 3ED2} = {7, 21ED2} = 400 [cent]
etc.

When prime numbers are combined, the resulting tunings retain the generator intervals of each tuning, but an operation of subtraction between the [cents] quantities is performed to obtain the generator interval of the resulting tuning.

For example, when combining {1, 2ED2} with {1, 3ED2} to obtain the interval {1, 6ED2}, the subtraction of [cents] is performed:

{1, 2ED2} x {1, 3ED2} = {1, 6ED2} = 200 [cent] (600 – 400)

Thus, 6-ED2 shares the intervals of the prime factors that generate it and adds two new ones that are not present in the primes:

{1, 6ED2} = 200 [cent]
{1, 3ED2} = {2, 6ED2} = 400 [cent]
{1, 2ED2} = {3, 6ED2} = 600 [cent]
{1, 3ED2} = {4, 6ED2} = 800 [cent]
{5, 6ED2} = 1000 [cent]
etc.

3. Despite being a pioneer and revolutionary figure in his field, Julián Carrillo was also deeply influenced by his local context, as he demonstrates in relation to microtonal music, where he allegorically positions himself as a Spanish colonizer discovering America. This is an archetype he used at various points throughout his career, which contrasts with the material conditions under which this artist developed his proposal for "Sound 13." Similarly, this is evident in the way European and Euro-American audiences perceived Julián Carrillo's work when they first encountered it. Stokowski expressed it directly: “Fortunately for America, we do not need to look to European musicians for this revolution, since we owe everything to an Indian descended from the children of this continent.” It is

clear that, in reality, Julián Carrillo, with his exotic ideas, represented the role of the indigenous person being discovered rather than the colonizer. However, both Julián Carrillo and Western opinion fail to achieve a full appreciation of the riches of the new world that are mutually revealed. The dominant viewpoint in the West tends to regard the indigenous and native cultures of America as objects of study or curiosities to be preserved in museums, historically assigning little value to their role as part of a living and dynamic culture. This perspective is also replicated in the institutions where research and ideas are produced, perpetuating theories and practices that no longer adapt to the verifiable realities revealed by the research itself.

We can verify that studies on the customs and languages of the peoples of America were scarce before the 19th century, and when they did exist, they were completely guided by the interests of foreign authors. Only in the 20th century were works published in greater numbers from the perspective and interests of native authors. Now, in the 21st century, faced with the accumulation of a vast amount of documents that speak to the rich intellectual life of Native America, there is growing appreciation for indigenous heritage as a millennial legacy that we must recreate. However, significant efforts remain to be made to democratize access to knowledge and research. It is within this context that the theory of Sound 13 is situated. In 1925, governments across the Americas were working intensively to promote a national discourse through propaganda networks that pushed patriotic narratives. Particularly in Mexico, the established discourse oscillated between the Hispanic, the mestizo, and the indigenous, each inscribing its own field of action and its own seasons, with varying advances, setbacks, and common points. From this, we can see how the established power encourages artistic creation that reinforces its narrative. Julián Carrillo benefited from this and traveled to Europe, like other artists, to further his studies in composition. Meanwhile, from opposition to the government, a clear musical trend rooted in folklore emerged, where popular song sought to highlight historical figures and moments, especially from the trenches of Emiliano Zapata, some of whose manifestos were written in the Nahuatl language. However, we can verify that his ideas were aimed at uniting all national identities: “To redeem the indigenous race, returning their lands to them, and thus their freedom; to ensure that the rural worker […] becomes a free man and master of his destiny through small property ownership; to improve the economic, intellectual, and moral condition of urban workers.”

This is also clearly seen in the Manifesto of the Union of Technical Workers, Painters, and Sculptors, where arguments are made in such a direction, seeking unity among different discourses: “The triumph of the popular classes will bring with it a flourishing, not only in the social order but a unanimous flourishing of ethnic, cosmogonic, and historically transcendent art in the life of our race, comparable to that of our admirable autochthonous civilizations; we will fight tirelessly to achieve it.”

However, and this is a tendency we will also see later in Julián Carrillo’s discourse as a way to reinforce the revolutionary intention of the manifesto, when arguing, they resort to methods against which they find themselves confronted. In this sense, Attali provides a deeper analysis of this intersection between music and power in his book *Noise (1978)*: “The theorists of totalitarianism: all of them, without exception, explained that subversive noises must be prohibited because they announce demands for cultural autonomy, claims of difference or marginality: the concern for maintaining tonalism, the primacy of melody, the distrust of languages, codes, new instruments, the rejection of the abnormal, are found in all those regimes.”

In this sense, the Manifesto of the Union of Technical Workers, Painters, and Sculptors expresses a purifying intention in no uncertain terms, proclaiming through Siqueiros’ pen: “Any aesthetic manifestation alien or contrary to popular sentiment is bourgeois and must disappear because it contributes to perverting the taste of our race, already almost completely perverted in the cities.” This

once again leads to the contradiction between what spontaneously arises on the margins of the musical field and what seeks to establish itself as the most idealized representation of a ritualistic and communal expression of a group. Carrillo had a more elaborate intuition of this revolutionary inspiration within the artistic realm, but instead of defining himself by preserving a tradition, he sought the creation of new structures and new languages. On one hand, this poses the critique that considers his work as detached from the languages used en masse, and even regards this type of language as a mere mathematical elaboration without artistic application. But ultimately is a experimental tendency that is always emerging.

4. To put the content of this essay into practice, for the past couple of years, I have been working on various microtonal music projects, especially through digital means. For this purpose, I created a plugin to synthesize microtonal tunings, supported by a DAW. Initially, I reviewed various plugins that offer configurations for microtonal music; however, many of these applications have limitations that did not align with the experiments I was conducting, nor did they provide the information and results I was seeking. Therefore, after understanding the basics of how synthesis works, I set out to design a plugin using Pure Data to achieve customized results, while also gaining a detailed understanding of the processes taking place within the application itself. After researching different synthesis methods and developing a simple program for additive synthesis, I was able to confirm that one way to optimize synthesis to achieve an attractive timbral character was through modular synthesis. For now, I have replicated a model similar to that of the Yamaha DX7, but this system is still designed for electronic support. Currently, digital support allows for different possibilities. There are already synthesizers taking advantage of these possibilities, such as Vital, which incorporates configuration options and the integration of audio samples that are only possible in the digital environment. Additionally, more advanced functions will be integrated into my microtonal synthesizer in future updates. The patches I have developed are “xsynth” and “xem”; the first allows control of modules using additive synthesis, while the second is a system much more similar to the DX7, using algorithms to connect the modules. These can be found on patchstorage.com as Pure Data files compatible with Camomile.

Regarding composition, it is possible to find patterns similar to those that form the basis of harmony. In particular, there are intervals that can be associated in the context of a tuning as dominant tones, usually their proximity to the 7th degree of 12-EDO marks the similarity, but this is a topic for further exploration.

5. In conclusion, we are once again at a historical moment where technological resources are optimal for musical experimentation, and where theories and narratives need reconstruction. Music has always played a role in the culture of peoples; sound production has been both a collective effort and a personal process of composition and motif development. This development, when centered around a system like the 12-EDO equal temperament tuning system, allows for the production of an infinite number of works, but it will always be an infinity of works within the same production model. Therefore, if new tunings are incorporated, creative momentum will eventually seek new boundaries amidst the overwhelming noise, leading to the creation of works with potential that is unimaginable today.

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